



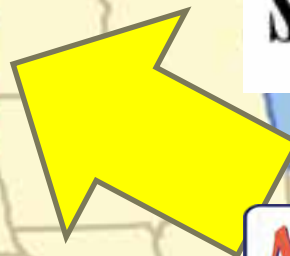
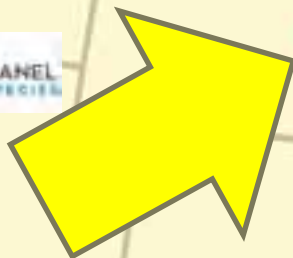
SOUTH DAKOTA GAME, FISH and PARKS

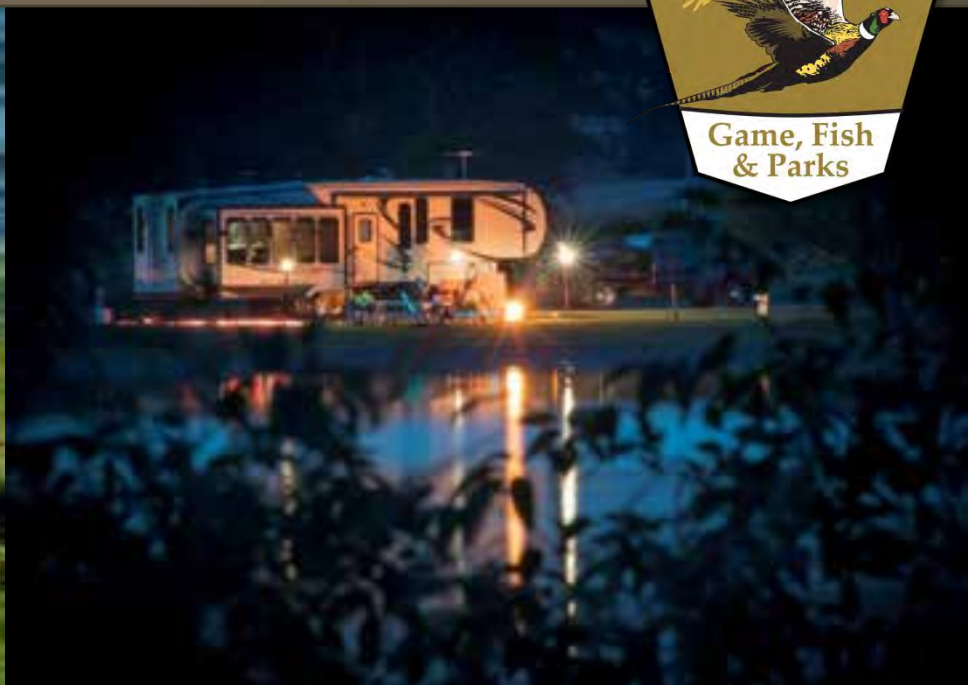
Aquatic Invasive Species Management In South Dakota



East & West Dakota?





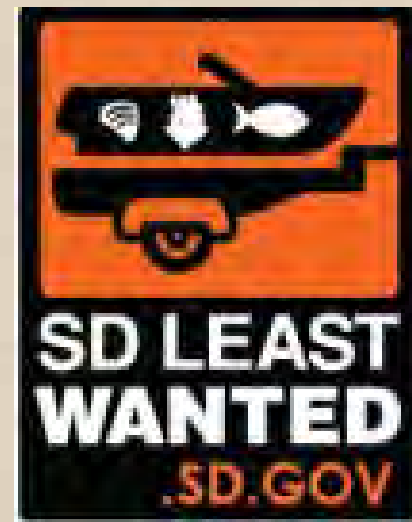


Hybrid AIS Management



Education & Outreach

- **SD Least Wanted Campaign**
- Boat ramp signs
- Digital and social media marketing
- Education events
- “Swag” items (shirts, stickers, etc.)
- Fishing and Boating Handbook
- Outreach Partnerships



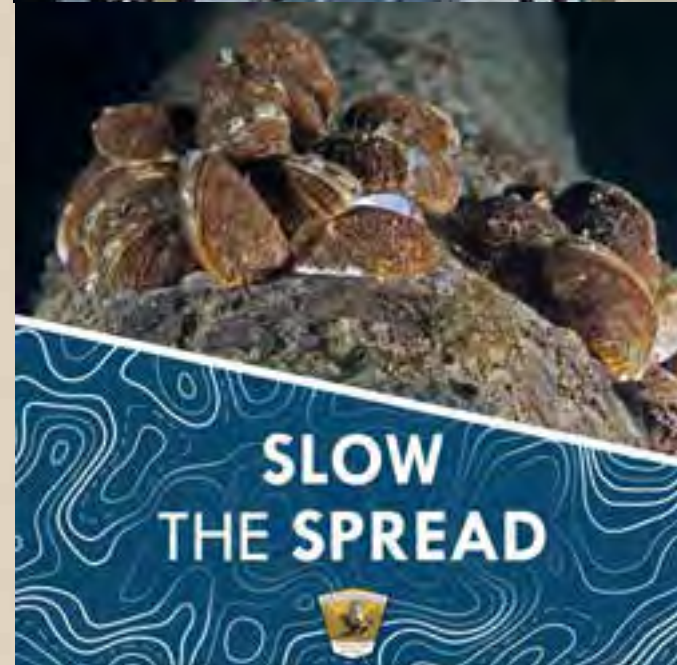
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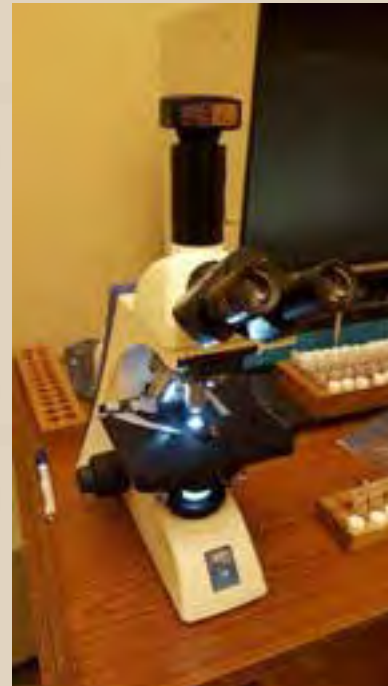
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Prevention

- Standard AIS Sampling



Prevention

- Rapid Response



Enforcement & WID

- 14, 556 Watercraft inspections
 - 583 watercraft using infested waters within 14 days

239 citations

183 warnings



2020 Legislation

- Mandatory WID
- Mandatory removal of all plants, animals, mud
- Increased fines for multiple violations
- Roadside inspection stations







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SOUTH DAKOTA GAME, FISH and PARKS

Bighorn Sheep Recovery-MAFWA

June Meeting 2022

Chadwick P. Lehman, Ph.D., Senior Wildlife Biologist, SDGFP



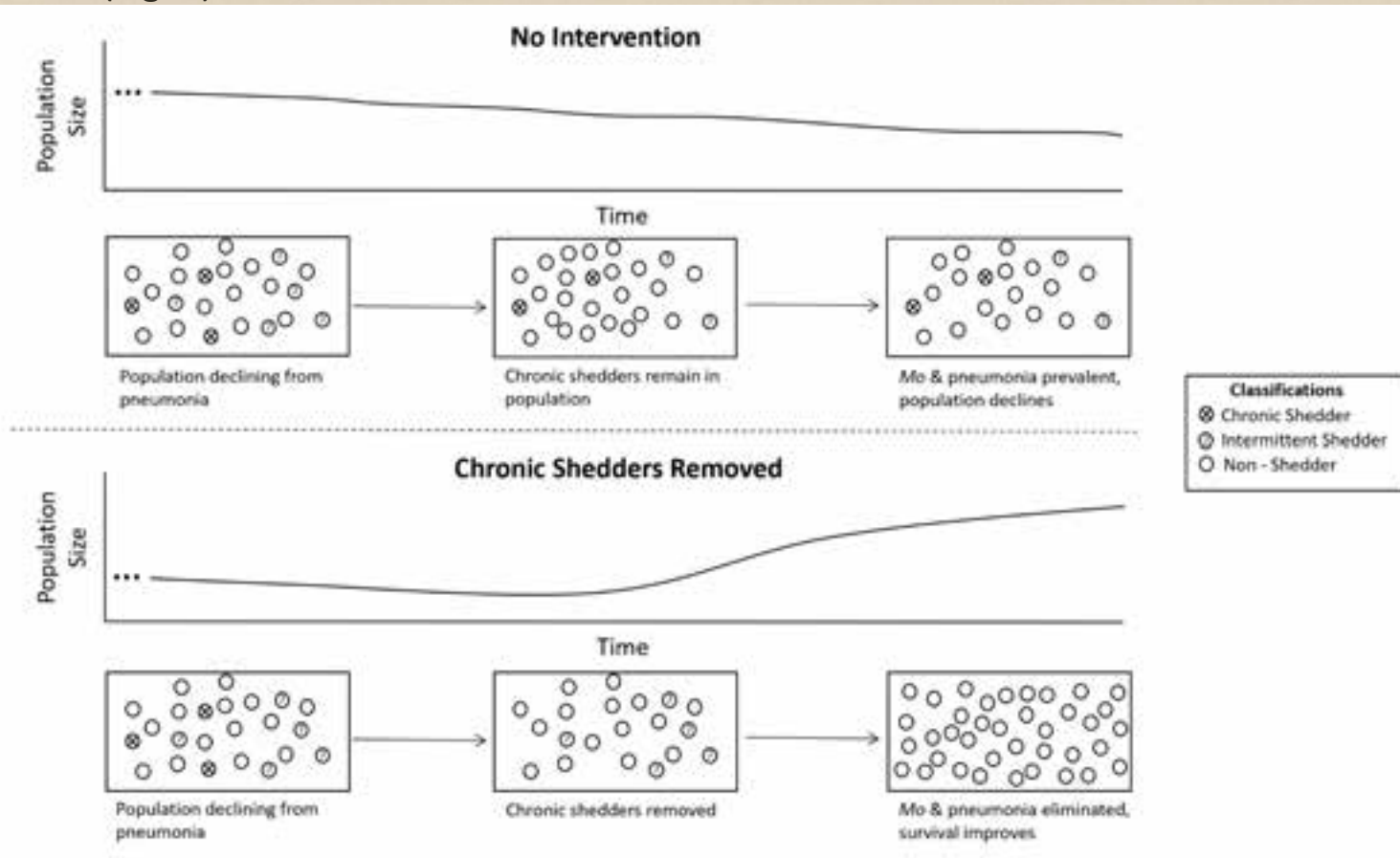
Background- South Dakota Bighorn Sheep

- Bighorn sheep (*Ovis canadensis*) populations in South Dakota declined precipitously following reintroductions in the early 1900s.
- Pneumonia die-off occurred in Custer State Park in 2004 (90%).
- Pneumonia die-off occurred in Rapid City herd in 2009 (50-60%).
- Pneumonia die-off occurred in Deadwood herd in 2016 (50-60%).

Chronic Carrier Hypothesis



Affected bighorn sheep herds show high *Mycoplasma ovipneumoniae* exposure (hereafter *M. ovi*) (median seroprevalence = 67%) but lower shedding prevalence (median = 22%; Cassirer et al., 2018). Plowright et al. (2017) found that about half of bighorn sheep testing *M. ovi* positive, consistently shed the pathogen, implying chronic carriage. We therefore hypothesized that pneumonia could be maintained in bighorn sheep populations by a minority of identifiable, chronically shedding individuals (Fig. 1).



Custer State Park Case Study

Removal of chronic *Mycoplasma ovipneumoniae* carrier ewes eliminates pneumonia in a bighorn sheep population

Accepted in Ecology and Evolution

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Jonathan A. Jenks, *South Dakota State University*



Objectives

- We tested the hypothesis in free-ranging bighorn sheep populations in South Dakota, USA: the Custer State Park (CSP) treatment population and the Rapid City (RC) control population (Fig. 2). Our objectives were to 1) determine if removing chronically carrying individuals would reduce the prevalence of *M. ovi* shedding, and 2) ascertain whether chronic carrier removal reduced pneumonia-related mortality.



Materials and Methods



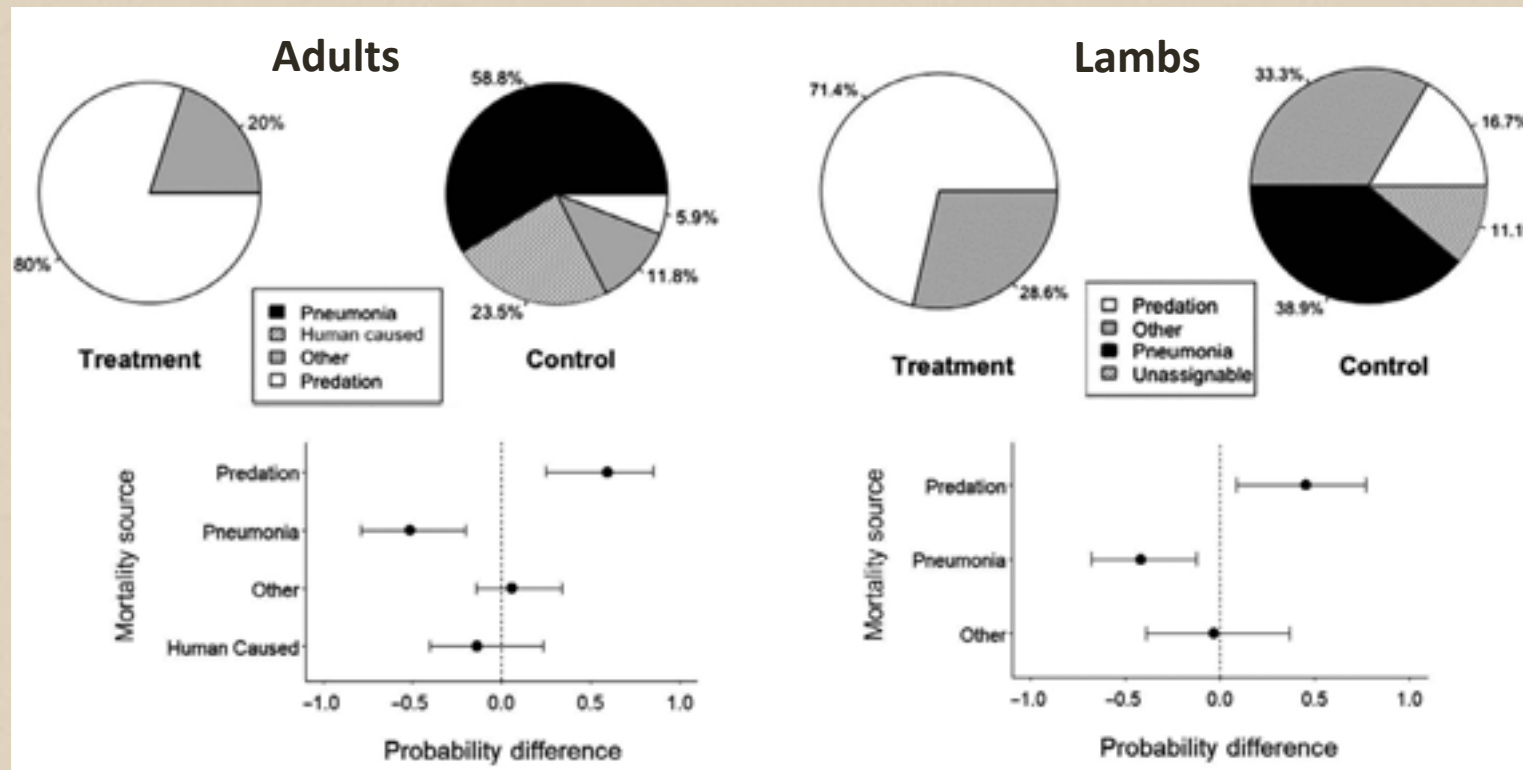
- We captured bighorn sheep via chemical immobilization or aerial net-gunning.
- Placed VHF transmitters on adults and lambs.
- Used VITs in pregnant ewes to facilitate capture of lambs.
- During capture, we collected information on sex, age, *Movi* carriage and antibodies, and presence of other pathogens. Blood collection for serum.
- We collected *M. ovi* mucosal samples via three swabs, where one was immersed in Tryptic Soy Broth. To detect polymicrobial infections, we rotated 3 additional swabs along each tonsillar crypt and stored them similarly to nasal swabs.



Results- Adults



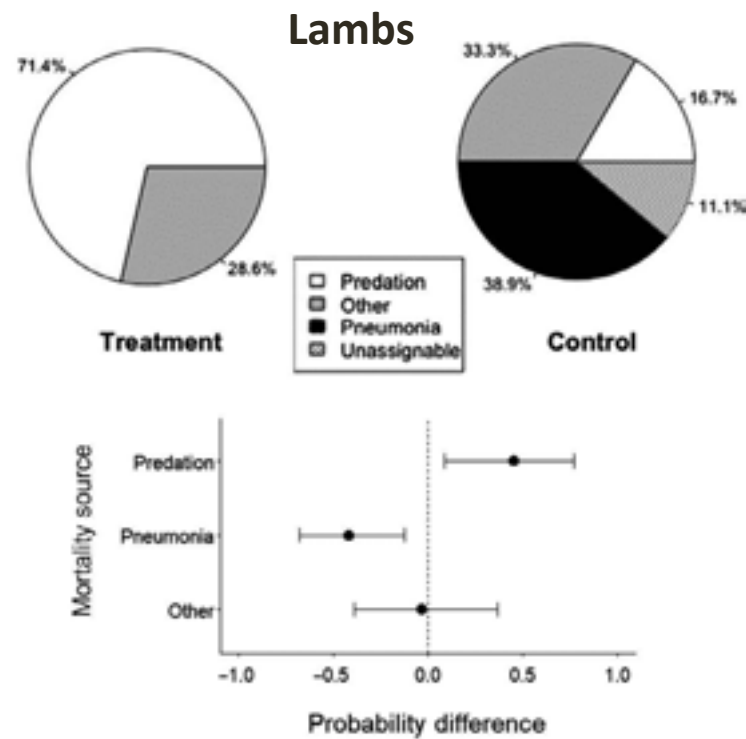
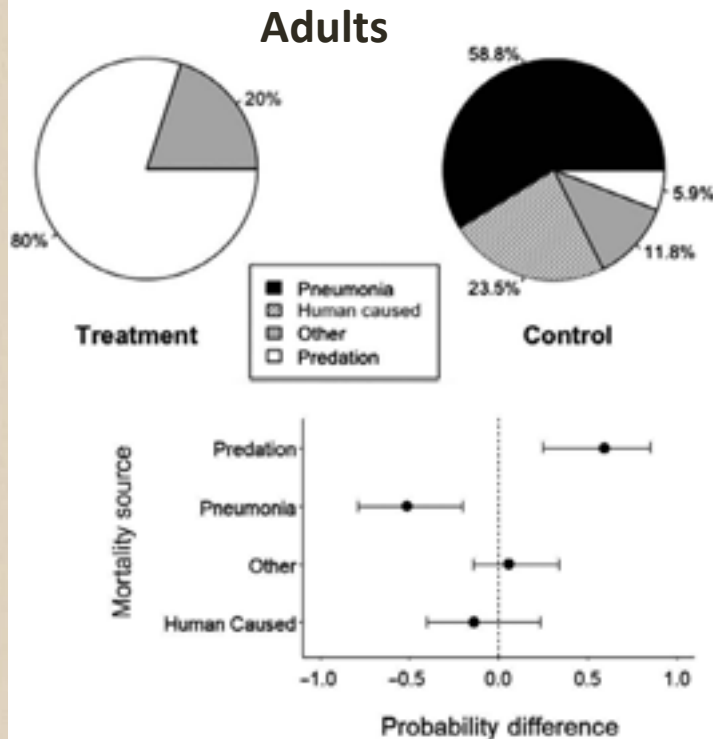
- Pneumonia mortality hazard for treatment population adults was significantly reduced relative to control (Probability difference = -52%, CI = -78%, -15%). Pneumonia caused less adult mortality in the treatment population (10%, CI = 0%, 41%) than in the control herd (61%, CI = 36%, 84%). Conversely, predation caused significantly more deaths in the treatment population (61%, CI = 36%, 84%) than in the control (10%, CI = 2%, 27%; probability difference = 51%, CI = 13%, 83%).



Results- Lambs



- We analyzed mortality data on 43 lambs. Chronic carrier removal had a negative effect on daily lamb hazard (72% reduction in the treatment population, CI = 36%, 91%). This corresponds with a 77% annual survival rate (CI = 26%, 96%) in the treatment population and 35% (CI = 12%, 62%) in the control.
- Pneumonia-caused mortality was significantly less likely in the treatment population (probability = 6%, CI = 0%, 29%) than in the control population (probability = 48%, CI = 24%, 73%), with a probability difference of -37% (CI = -59%, -1%).



Deadwood Case Study



- Population of 25 sheep remaining.
- 2021 lamb recruitment appeared to be rebounding (30% in 2021 versus 6% in 2018).
- Tested 18 of 24 individuals within this herd, without testing 1 ewe, 3 lambs, and 2 rams in 2020-21. There was one indeterminate in this herd in 2020-21.
- In 2021-22, a bighorn lamb was picked up dead and tested positive for *M. ovi*. All PCR *M. ovi* tests were negative with the exception of one indeterminate.
- SDGFP removed the one indeterminate ewe in 2021-22 and hopefully this herd will now fully recover.



Photo Credit: Patricia Bringman

Rapid City Case Study

- At the start of this study, the Rapid City BHS herd had 22 ewes and 12 rams, ending with 13 ewes and 10 rams.
- The Rapid City herd received the test and removal treatment from 2018-2020 and historical Rapid City herd data was used as a pre-treatment comparison.
- **9 chronic carriers** (8 ewes and 1 ram) were removed from the Rapid City herd.
- 66 nasal mucosal swabs were tested with *M. ovi* PCR.
 - 46 Negatives
 - 11 Positives
 - 9 Indeterminates



Adult Results

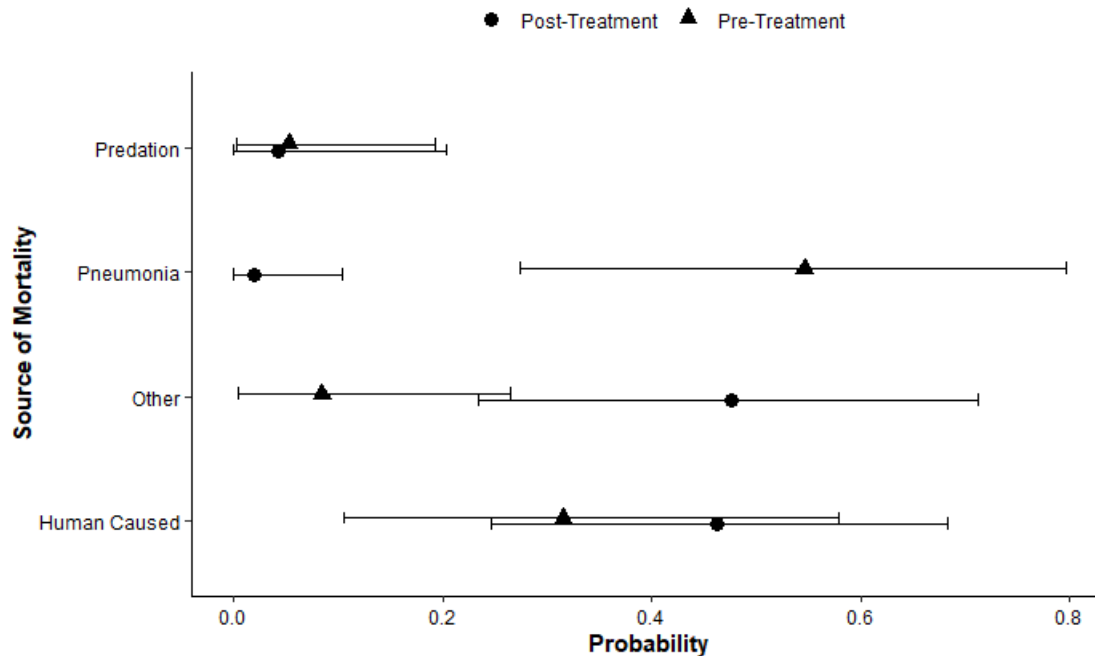


- Top competing adult survival models based on WAIC ranking:

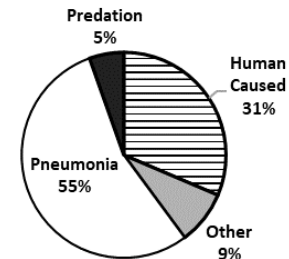
$$\ln(\Lambda_{ij}) = \gamma + \beta_{\text{test}} \times \text{test}_i + \rho_j \quad (w_i = 0.524)$$

$$\ln(\Lambda_{ij}) = \gamma + \beta_{\text{treatment}} \times \text{treatment}_i + \beta_{\text{test}} \times \text{test}_i + \rho_j \quad (w_i = 0.463)$$

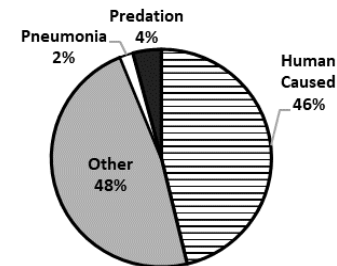
- $\beta_{\text{treatment}} = -1.64$ (CI -3.86, 0.36)
- $\beta_{\text{test}} = 1.16$ (CI 0.46, 1.90)
- Survival**_{pre-treatment} = 88% (CI 79%, 95%)
- Survival**_{post-treatment} = 87% (CI 78%, 93%)
- No pneumonia-related adult mortalities were documented after the start of treatment.



Pre-treatment



Post-treatment



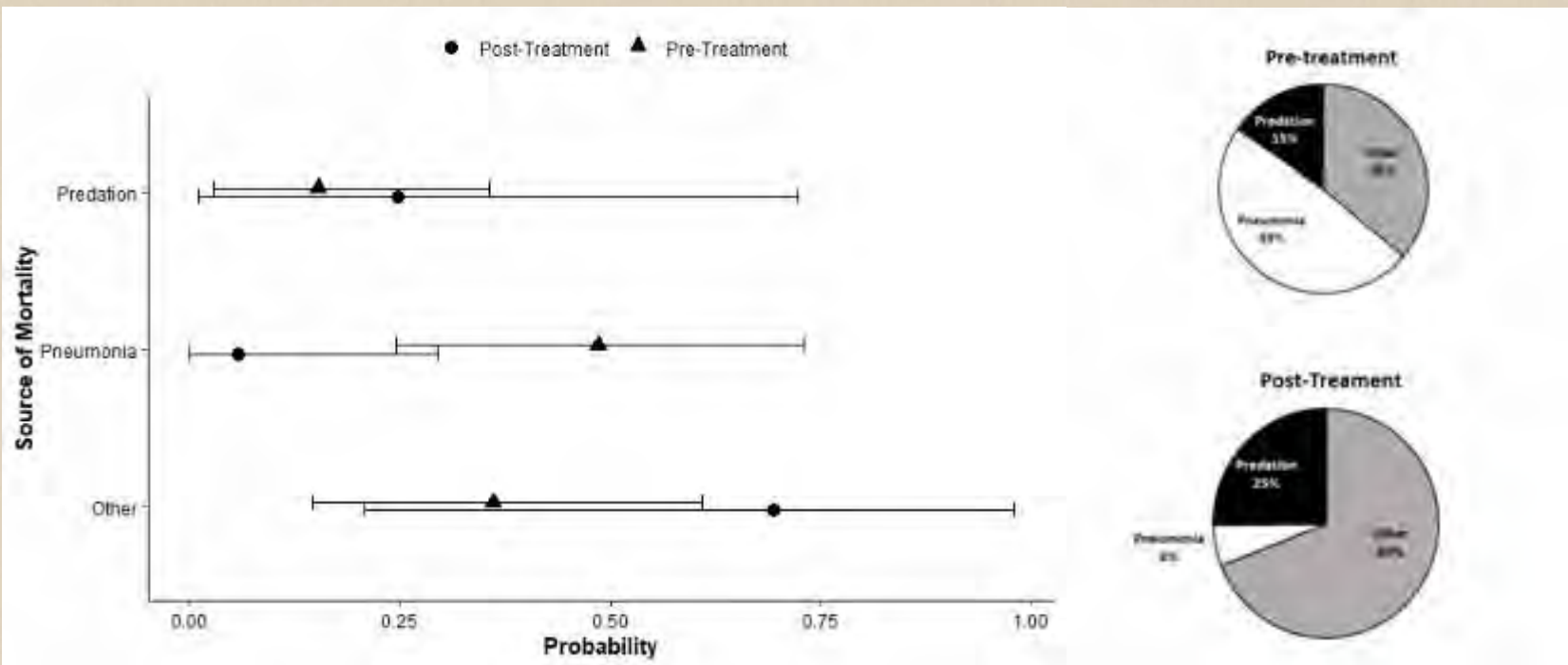
Lamb Results



- Most supported lamb survival model based on WAIC ranking:

$$\ln(\Lambda_{ij}) = \gamma + \beta_{\text{treatment}} \times \text{treatment}_i + \rho_j \quad (w_i = 0.802)$$

- $\beta_{\text{treatment}} = -1.23$ (CI -2.11, -0.42)
- Survival**_{pre-treatment} = 21% (CI 8%, 37%)
- Survival**_{post-treatment} = 62% (CI 41%, 81%)
- No pneumonia-related mortalities were documented after the start of treatment.



Discussion

- In our experimental case studies, we found that pneumonia can be maintained in a free-ranging bighorn sheep population by a few individuals which chronically carry *M. ovi*. After removing these individuals, we detected no deaths attributable to pneumonia in the treatment population.
- We found that adult survival in the control population averaged 10% lower than in the treatment population, which we attributed to additive pneumonia-induced mortality in Custer State Park. We did not see this occur in the Rapid City herd (similar survival before and after treatment). Lamb survival was significantly higher in our treatment populations.
- Given the cost of identifying chronic carriers, wildlife managers might question whether complete depopulation followed by repopulation may be preferable to selective removal. While depopulation removes the pathogen along with its host, ensuing reintroductions may not be successful (Griffith, Carpenter, & Reed 1989). Population-level knowledge also appears to accumulate and transmit across generations (Jesmer et al., 2018), affecting a population's ability to follow green-up, avoid predation, and maintain complex migration routes. This knowledge has implications for population fitness and is lost with depopulation.
- Our bighorn populations are easily accessible through our abundant roads and facilitated the T&R management strategy.

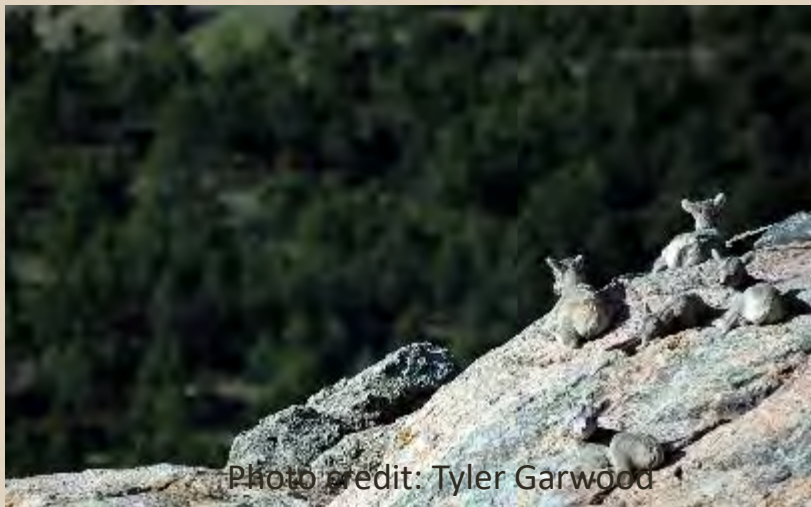


Photo credit: Tyler Garwood

Questions

